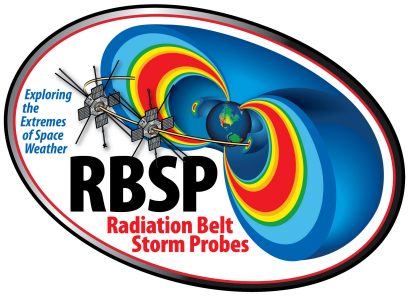
Geoscience Current and Future Space Weather Plans



Mona Kessel[1] and Shing Fung[2]

[1] NASA Headquarters

[2] Geospace Physics Laboratory, NASA GSFC

Contributions by Elsayed Talaat and Masha Kuznetsova

See also *The Radiation Belt Storm Probes and Space Weather* by Kessel et al., Space Sci Rev DOI 10.1007/s11214-012-9953-6

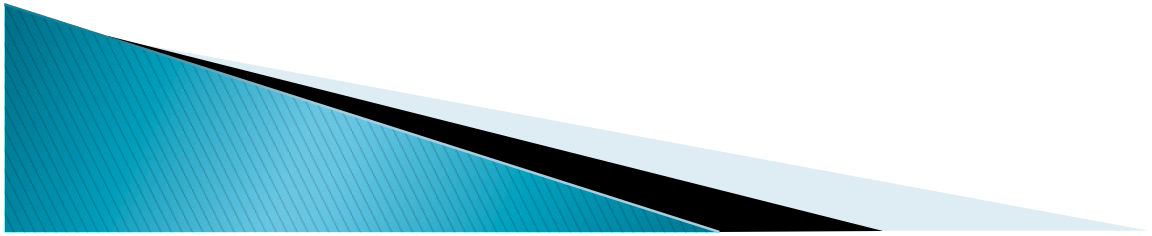
2014 LWS Science Meeting Portland OR, Splinter Session S-1 (4b)

National Space Weather Strategic Plan [2010]:

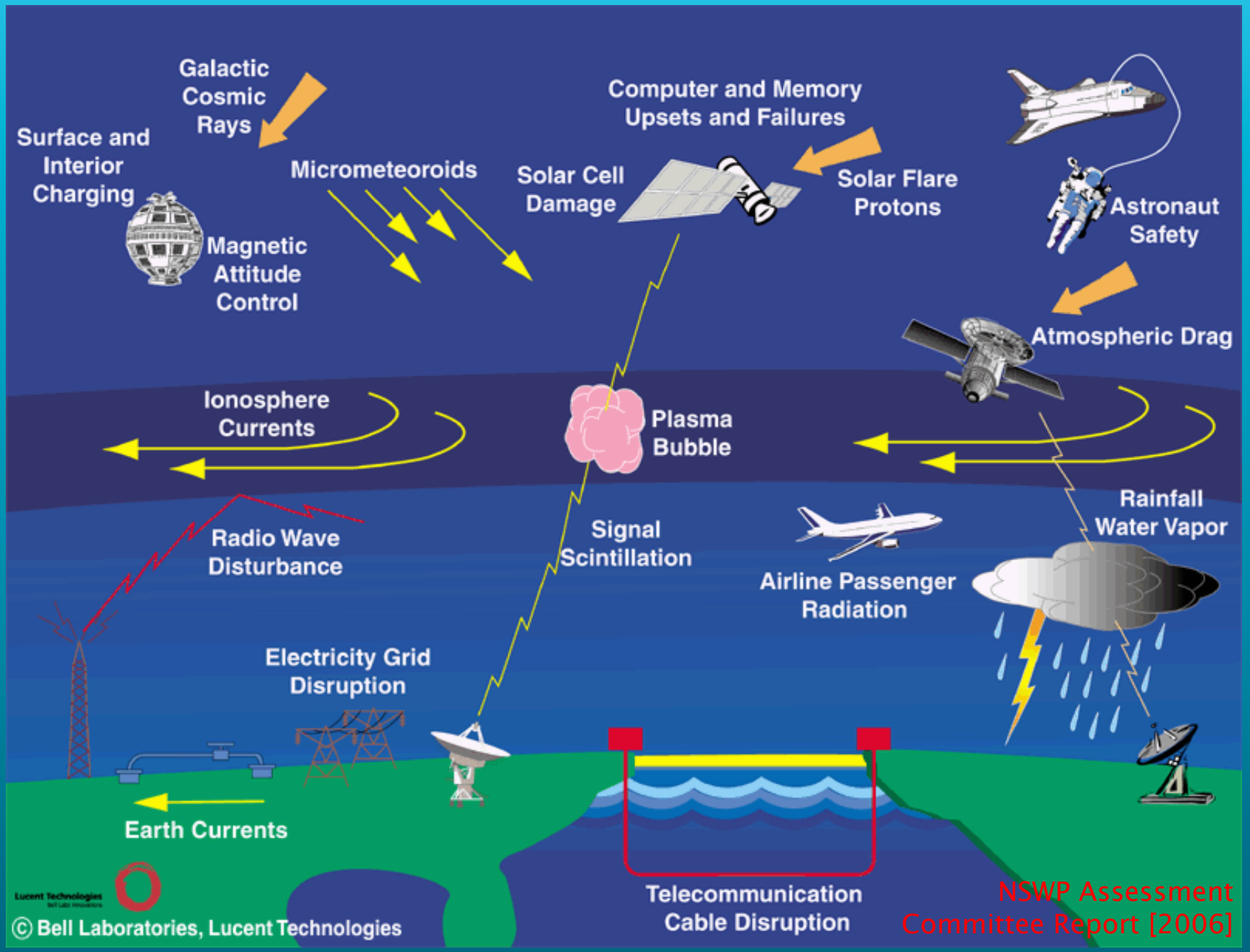
"Space weather" refers to the variable conditions on the Sun, throughout space, and in the Earth's magnetic field and upper atmosphere that can influence the performance of space-borne and ground-based technological systems and endanger human life or health.

In other words:

Space weather refers to the solar-terrestrial environment conditions that can cause *adverse effects* on technological systems and life, in space and on Earth.



Space Weather Impacts in Geospace

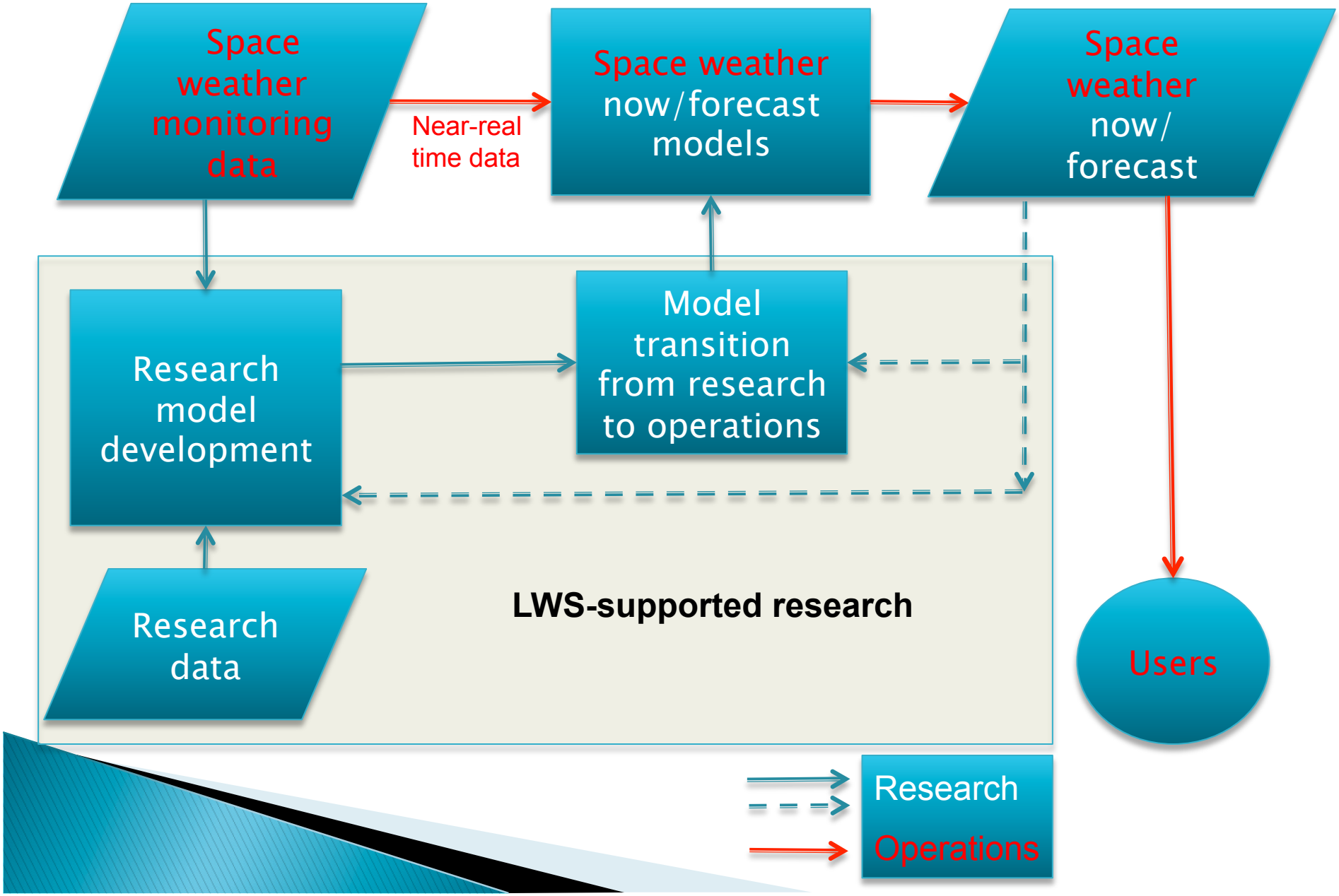


Space Weather: NASA's Role

Specific to space weather, NASA formulates and implements a national research program for understanding the Sun and its interactions with the Earth and the Solar System and how these phenomena impact life and society

NASA Living With A Star Program Goal:
To develop the *scientific understanding* to address those aspects of the Sun-Earth system that *may* affect life and society.

Pathway to Space Weather Prediction



Current Suite of Space Weather Observing Systems

SPACE SENSORS

DOD	CIVIL
NASA	Foreign

STEREO-A&B (NASA)
1AU Solar orbit
- Solar imaging
- Solar wind & particles

SOHO (NASA/ESA)
- Coronal imaging
- Solar wind
- Solar particles

ACE (NASA)
- Solar particles
- Solar wind
- Interplan. mag field

DSP
- Energetic particles

GPS
- Energetic particles

DMSP
- Energetic particles
- Auroral imaging
- Electron and Neutral Density profiles

Solar Dynamics Observatory (NASA)
- Solar Imagery
- Solar magnetic field

Classified Sensors

C/NOFS

COSMIC
(NOAA / Taiwan)
- Ionospheric

GOES (NOAA)
- Magnetic fields
- Solar x-rays
- Energetic particles

Iridium / AMPERE
(Commercial/ NSF)
- Magnetometers

POES & MetOp
(NOAA / Eumetsat)
- Energetic particles

Van Allen Probes
- Energetic particles
- Magnetic field
- Plasma waves

Orbit Areas

- Solar
- L1
- GEO
- LEO

GROUND-BASED SENSORS

- Neutron Monitors
- Riometers
- Next Generation Ionosonde
- GNSS Receivers
- Solar Optical Telescopes
- Ionospheric radars (NSF)
- Radio Solar Telescopes
- Scintillation Network Decision Aid
- Magnetometer Network (USGS)

Adapted from: Report on Space Weather Observing Systems: Current Capabilities and Requirements for the Next Decade
OFCM – NSWPC JAG for SEGA [2013]

Space Weather data

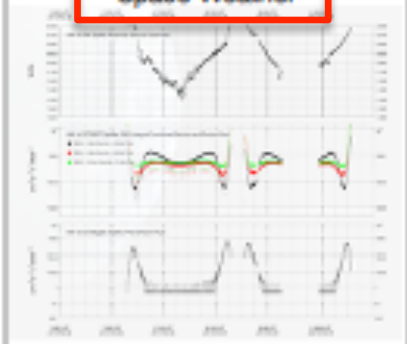
http://athena.jhuapl.edu

Van Allen Probes
SCIENCE GATEWAY

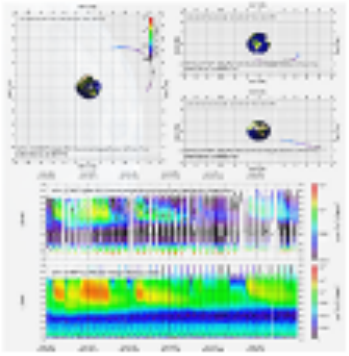
SCIENCE GATEWAY: OVERVIEW

The Science Gateway provides access to data, models, software and tools in support of the Van Allen Probes mission for researchers, students and the general public.

Space Weather



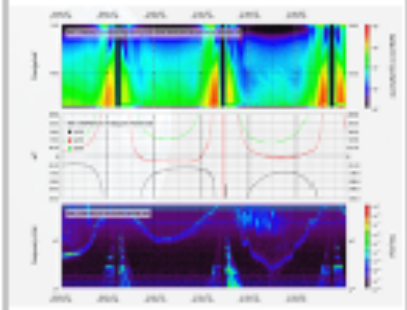
L-Shell Context



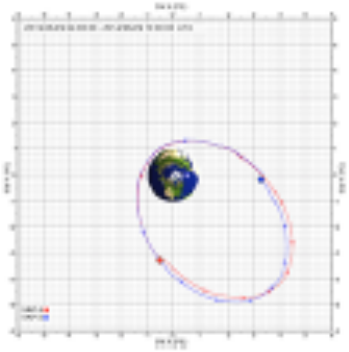
SOC Links

Bibliography

Summary Plots



Orbit Plot



ASCII Orbit List

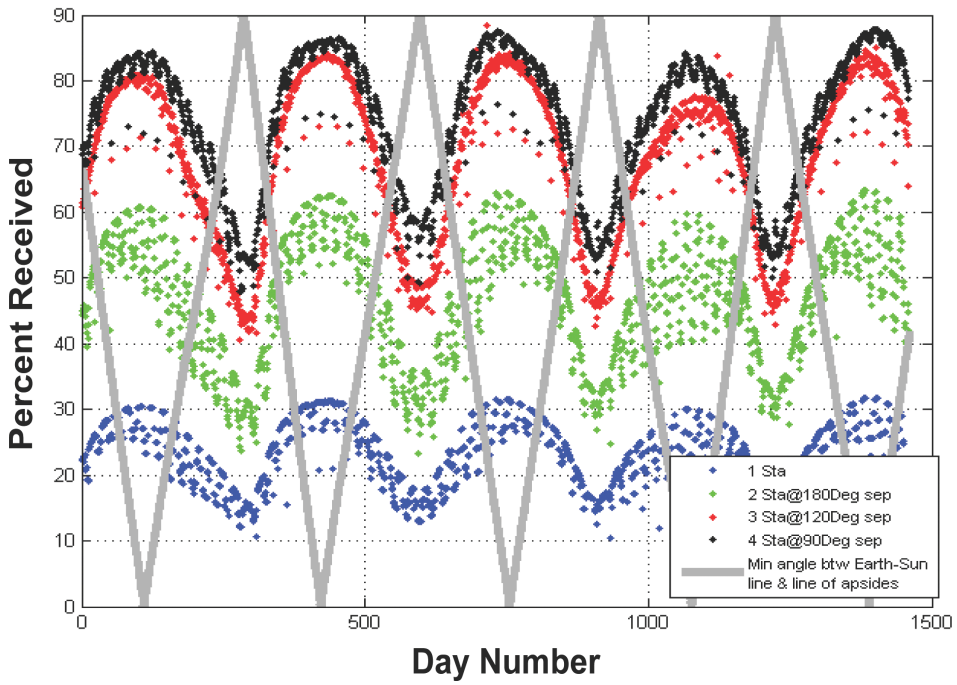
Magnetic Footprint

Van Allen Probes Space Weather Data

- Targets the Earth's radiation belts as a part of the space weather chain
- Broadcasts space weather data 24/7 when not sending science data
- Enables determination of the radiation-belt response to solar storms

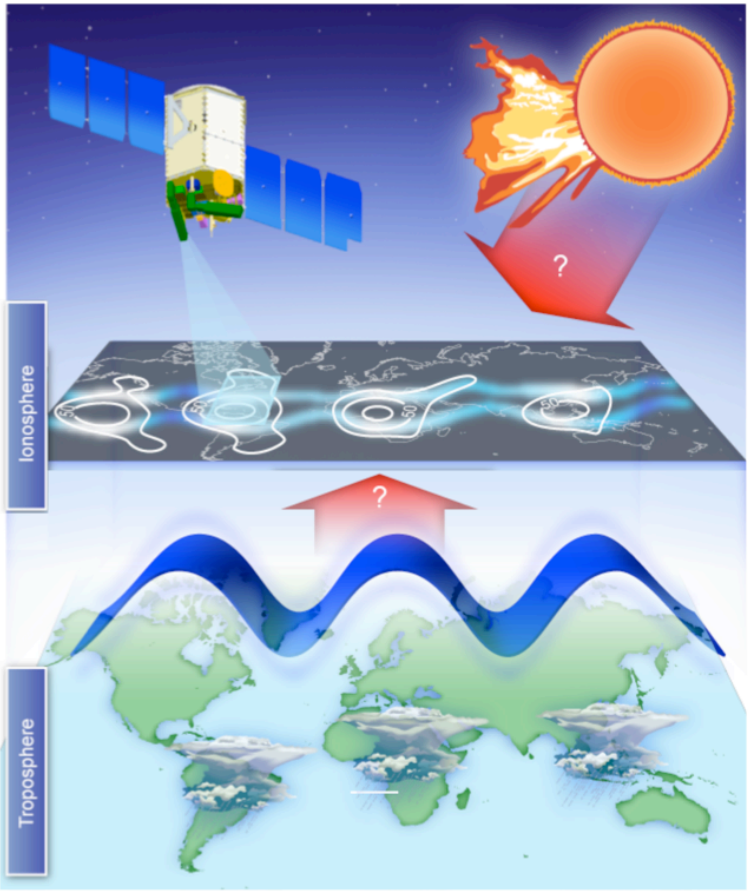
Increasing ground-station coverage will increase real-time data capture rate.

- Agreements in place with 2 ground stations (spacecraft A)
  - a) Korea Astronomy and Space Science Institute – specially built for Van Allen Probes
  - b) Czech Republic
- Discussions underway with other sites
  - Alaska, Brazil, Argentina, Germany

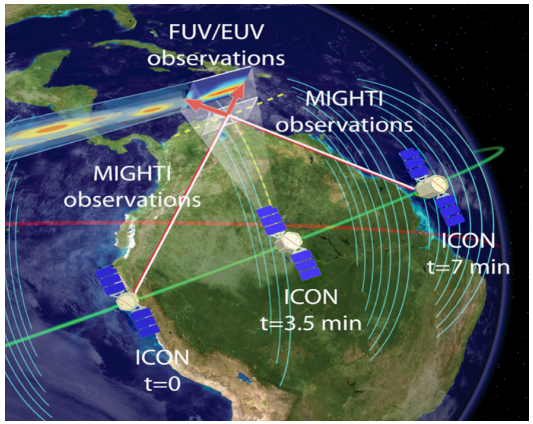


ICON

Ionospheric Connection Explorer



- Uses imaging and in-situ techniques to targets the low-latitude ionosphere
  - Atmospheric waves driven from below
  - Space plasma density produced by sunlight & confined by the magnetic field
- Determines how the ionosphere responds to "space weather" drivers from the sun in concert with weather on our planet.



See Splinter Session S-19 (3a): *Immel et al.*, "Search for the Drivers of Ionospheric Variability"

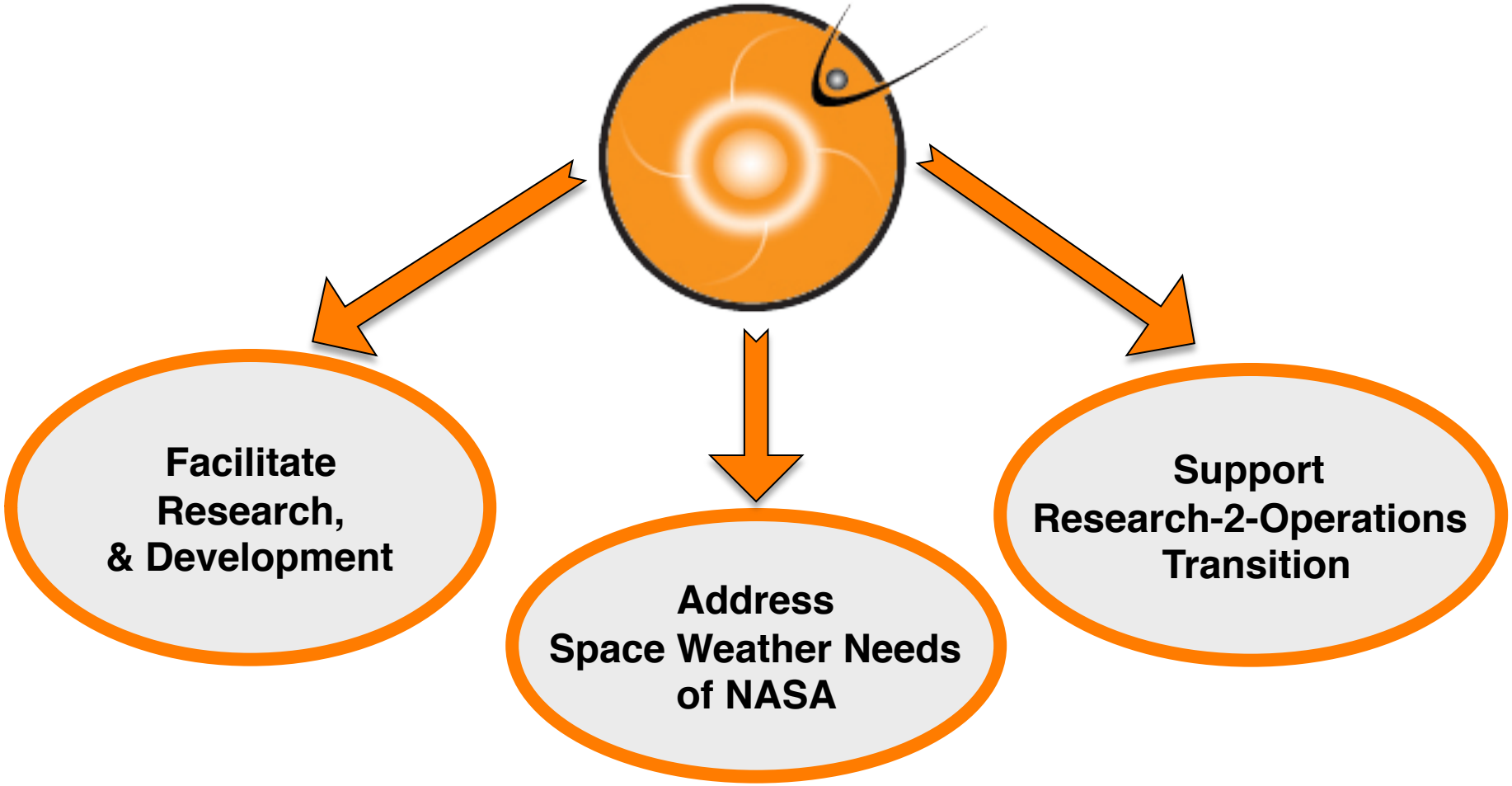
GOLD Global-scale Observations of the Limb and Disk

A Mission of Opportunity that will:

- Image the upper atmosphere from geostationary orbit;
- Study the weather of the thermosphere-ionosphere
- Measure temperature and composition that are important for satellite drag, and ionospheric disruptions of communication and navigation

See Plenary 3a: *Eates et al.*, "*Observing Earth's Response to Solar Variability with the GOLD Mission*"

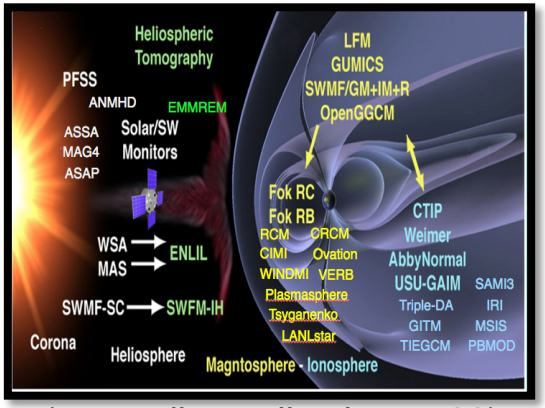
Community Coordinated Modeling Center (CCMC <http://ccmc.gsfc.nasa.gov>)



Core CCMC Partners: International Research Community, Model Owners, NASA Engineers and Mission Specialists, Operational Space Weather agencies (NOAA, DoD, UK Met Office).

CCMC Assets & Services

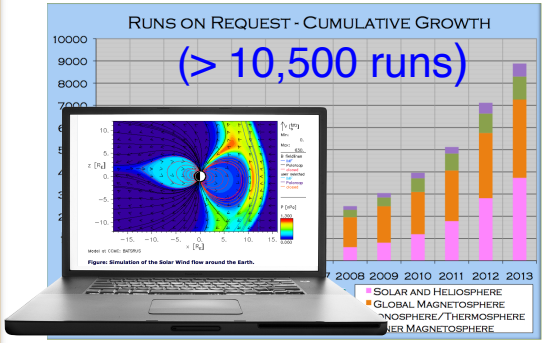
Models



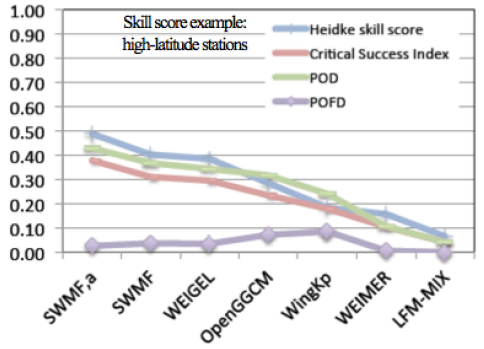
(expanding collection: > 60)

Simulation

Services



Assessment, Metrics & Validation



Multi-Purpose **Tools, Systems, Databases**

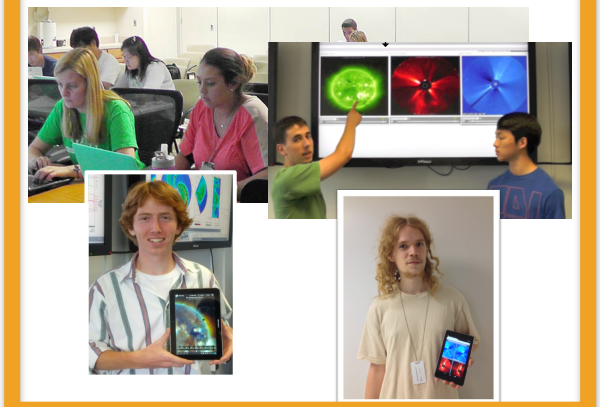
SEA[5]

Space Weather Services

for NASA's missions

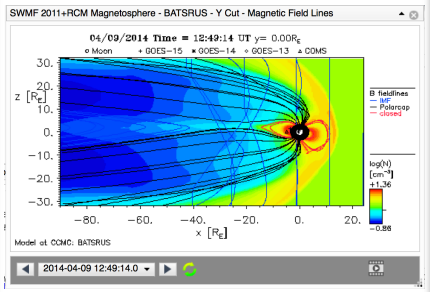
Space **W**eather **R**esearch **C**enter

Hands-on **Education**



Examples of Tools, Systems & Databases
for Research Analysis, M&V, Forecasting.

Continuous Real-time Simulations



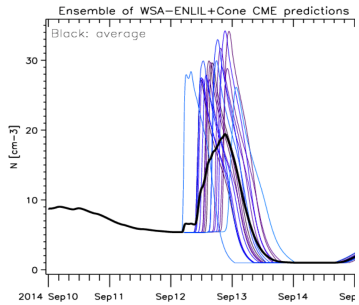
Event-Triggered Real-time Simulations

1-Click

Input Parameters Generation Tools

StereoCAT

Ensemble Simulations



iNtegrated Space Weather Analysis System

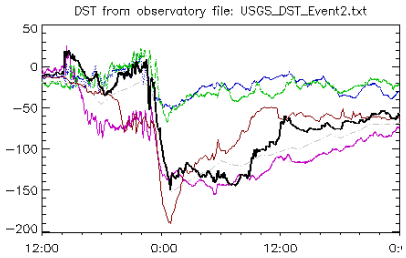
Databases:

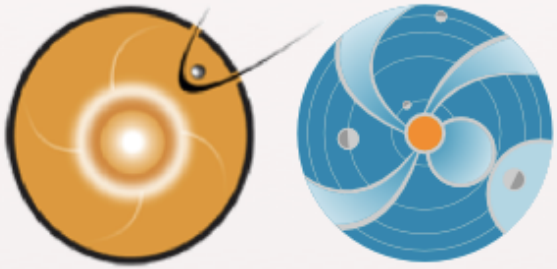
Run Results, Events, Impacts interpretations

DONKI

Forecasting Methods ScoreBoards

M&V Suite to Trace Model Improvements





NASA Goddard Space Weather Research Center

<http://swrc.gsfc.nasa.gov>

Key objective: to provide the latest space weather information (incl. research nowcast & forecast) to NASA's robotic mission operators and partners.

Products & services

- Space weather information—Sends out research forecasts of space weather conditions
- Models—Provide forecasts and information for areas where we have no actual measurements
- Spacecraft anomalies reports—spacecraft anomaly resolution support and space weather products for individual missions
- Space weather scoreboard—Tracking CME arrival time predictions
- Tools—Integrated Space Weather Analysis system (ISWA), web-based system for NASA-relevant space weather forecasts and space environment information
- DONKI—Space weather Database Of Notifications, Knowledge, and Information
- Mobile Apps—iOS & Android apps for viewing space weather data on mobile devices
- Social media—Connect with Twitter, Facebook, Google+, and Youtube

Concluding Remarks

- Geospace (upper atmosphere, ionosphere, the radiation belts) is the region with most assets susceptable to space weather effects.
- Large variations in energetic particles, electric currents, magnetic field, plasma and neutral densities can adversely affect technological and biological systems, in space and on the ground.
- The Van Allen Probes, launched in August 2012, have been key to providing crucial measurements for advancing radiation-belt science and characterizing the associated space weather impacts.
- ICON and GOLD, to be launched in 2017/18, will add new insights in how the atmosphere and ionosphere may respond to space weather conditions.
- Geoscience/space weather research will benefit from observations by the Heliophysics System Observatory [*Newmark's* talk in **Plenary 4b**].
- With increasing data coverage (space & ground) and better research models, in collaborations with space weather community the CCMC will be able to produce better operational models.